PRELIMINARY IDENTIFICATION ON KEY INDICATORS FOR AIR QUALITY RISK ASSESSMENT FROM LANDFILL

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Abstract
Landfilling is still the most widely used form of waste disposal although it is associated with a number of environmental issues primarily related to unregulated and partially controlled landfills that are numerous in Serbia. Landfill gas, mostly composed of methane, represents a high risk for human health and environment. This paper gives preliminary identification of criteria for quantification of methane risk impact on air in the immediate vicinity of landfills in Serbia. Four types of criteria were defined. Those criteria consist of sub-criteria that must be considered when considering the potential risks to the environment and human health.

Introduction
The basic landfill gas components are methane, carbon dioxide and trace concentrations of a wide variety of other gases that depend on the content of disposed waste. If methane as a by-product of municipal waste disposal is not collected and used as a renewable energy source, it is emitted into atmosphere with high global warming potential that is 23 times higher than carbon dioxide potential [1]. Thus, methane is considered to be one of the most significant greenhouse gases [2]. Each landfill carries certain health and environmental risks which depend on several factors such as the size and the age of the landfill, type of waste, water presence and geological conditions. Groundwater pollution, generation of landfill gas, odors, dust and noise are just some of the potential negative effects of landfills [3], [4]. If not controlled properly, landfill gas can spread below ground and pose a risk of explosion and suffocation in surrounding facilities. Thus, adequate landfill location i.e. maintenance of the distance between landfill and sensitive land is of crucial importance and it is an effective risk management measure [5]. Methane is very effective greenhouse gas and its uncontrolled emission into atmosphere can have an impact on atmospheric chemistry and climate thus significantly affecting ozone levels, water vapor, hydroxyl radicals and other numerous compounds [6]. According to EPA the default buffer requirements are not different for operating and closed landfills. However, the buffer for operating landfills serves to manage landfill gas risk and odor impacts while the buffer for closed landfills serves to manage the risk of landfill gas impacts only [7]. The aim of this paper is to make a preliminary identification of criteria for risk quantification of methane risk impact on air in the immediate vicinity of landfills in Serbia. Based on EPA environmental legislation and the legislation of the Republic of Serbia [8], four criteria types with certain sub-criteria were defined.

Results and discussion
There are 160 controlled and 3500 uncontrolled waste disposal sites in Serbia [9], [10], and only 5% of the total generated amount of the waste is recycled. Landfilling is a dominant waste disposal method. In order to minimize human health and environmental risks, these locations require closure and remediation. However, precisely because there is a large number of landfills

and lack of financial means, it is necessary to categorize the existing landfills based on its risk from the aspect of production and impact of methane on environment. In that sense, a preliminary identification of four criteria types was carried out. Those criteria consist of sub-criteria that are key factors for risk quantification.

The first criterion is related to source emission potential. Methane emission potential form landfill depends on several factors that were in this case taken as sub-categories: 1) **Landfill type -** there are only seven landfills in Serbia that meet the criteria defined by the EU Directive. Other landfills, where more than 80% of generated waste is disposed, have certain characteristics of sanitary landfill; 2) **The amount of landfill waste/ landfill size -** the greater the waste mass is, the greater is the amount of productive methane [11]. Data on dimensions and volume of landfill in the Republic of Serbia are not the most reliable because they are based on estimation and there is no relevant technical documentation for many landfills [10], [12]. The average waste production is 0.76 kg/cap/day; 3) **Landfill age -** this criterion primarily refers to whether the landfill is in the methanogenic decomposition phase; 4) **The composition of landfill waste -** over 50% of generated waste in Serbia contains biodegradable waste (garden waste or food). However, variations in the morphological composition of waste can occur at the local level depending on several factors (economic development and urban characteristics of the municipality, as well as the age and educational background of inhabitants) [12].

The second defined criterion is the landfill infrastructure. Monitoring of possible migrations of landfill gas is very important in order to avoid spreading among site facilities or locations along and accumulation of concentrations that can be hazardous to people or properties due to its inflammability and explosive potential. Thus, three sub-criteria were also defined: 1) **the presence of bottom landfill lining system** which role is to prevent gas penetration below landfill ground level; 2) **landfill cover type** - landfill management in Serbia mainly involves soil application as inert material and 3) **degassing system** - landfills mostly have passive degassing system exclusively due to explosion and fire prevention [12], [13].

The third criterion is related to landfills vulnerability on the environment and human health. Areas where there is a potential landfill impact on surrounding are defined as buffer zones. According to EPA, a reasonable default buffer distance is 500 m. When the distances are less than 500 m, the risk to the environment is considered to be low. According to SEPA surveys, out of the total number of landfills in the territory of the Republic of Serbia, 7.3% are located at distances less than 100 m from the settlements [10].

Potential methane concentration in ambient air is the fourth defined criterion. Given that the measurements are expensive, a preliminary estimation of methane concentration in ambient air could be done in faster and simpler way throughout modelling. The listed landfill characteristics and waste disposal are important factors that must be considered for the estimation of gas emission potential of the landfill site.

Conclusion

One of the biggest obstacles for solving problems related to waste management in developing countries is lack of funds. There is a great number of uncontrolled and non-sanitary landfills in the Republic of Serbia that must be remediated in order to reduce their negative impact on the environment and human health. Based on the defined criteria for environmental risk quantification it is possible to position landfills based on the risk they carry with the aim to firstly remediate the most critical ones. Landfill remediation is an expensive process and it cannot be performed for all landfills at the same time. Therefore, it is necessary to identify preferential landfills and, in that way, distribute funds.

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